THE EFFECTS OF FOREST FIRES ON THE STAND HISTORY OF NEW JERSEY'S PINE REGION

by S. LITTLE

NORTHEASTERN FOREST
EXPERIMENT STATION

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FOREST SERVICE

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Forest Management Paper No. 2 is one of a series of Papers on various subjects in the field of forest management research. This includes silviculture, fire, regeneration and planting, genetics and tree breeding, growth and related subjects. Other divisions of the Station will issue papers of a similar nature dealing with their specialties. These will take the place of the Occasional Papers previously issued by the Station.

Similarly, each Division of the Station will issue 1 or 2-page Notes, as the occasion demands, which will take the place of the old Station Technical Notes.

Forest Management Paper No. 2 summarizes the present knowledge on the effects of forest fires in the Pine Region of New Jersey. It is not the result of any one research project, but the combined result of research and observation. Its purpose is to acquaint foresters and others having some knowledge of forestry and conservation with the importance of forest fires and the part they have played in bringing the pine region of New Jersey to its present poor condition. It should form a background for future papers on results of more specific research into methods of renovating such stands.

It should be borne in mind that the facts presented here may not be applicable to other parts of the regional oak-pine type where climatic, growth and soil conditions are different and where the stands contain other species. It applies specifically to New Jersey's Pine Region.

THE EFFECTS OF FOREST FIRES ON THE STAND HISTORY OF NEW JERSEY'S PINE REGION

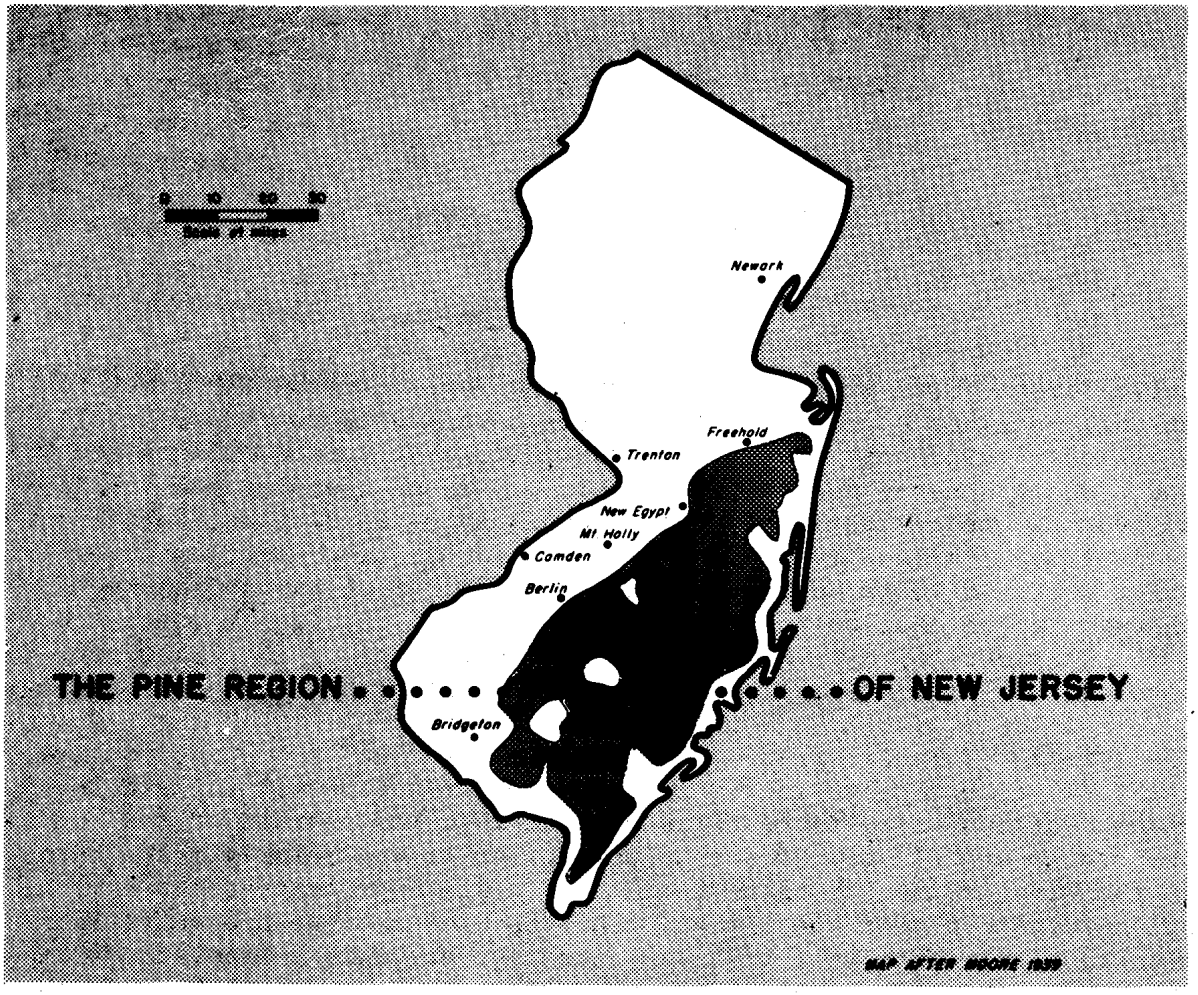
By

S. Little, Silviculturist

Large forest fires in the New Jersey Pine Region frequently make the spring headlines of nearby metropolitan newspapers, but hundreds of small ones throughout the year attract little attention. Fires are not a recent phenomenon in this section. Legends persist that Indians burned the woods extensively to improve hunting conditions (Lutz 1934, Moore 1939). Fires have apparently been common since settlement by white men, and it is definitely known that burns of ten to thirty thousand acres have been occurring periodically for eighty years (Lutz 1934 and recent fire records). Protective burning around cranberry bogs and buildings is a practice of long standing in this section.

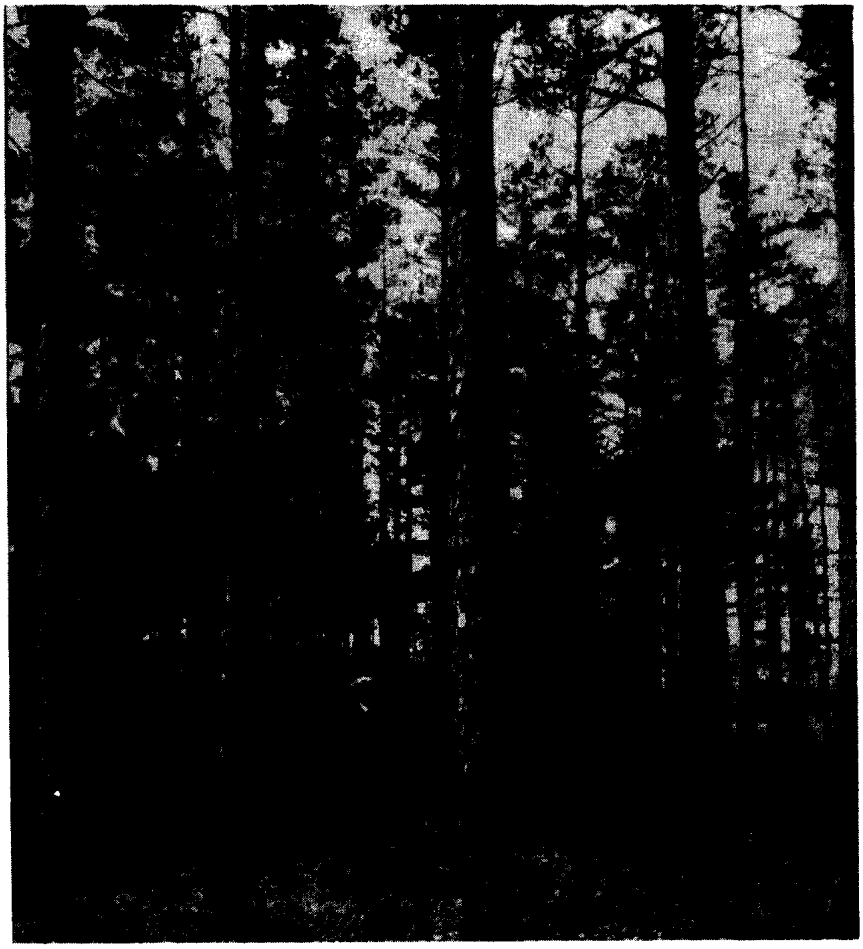
The effects of these fires on the forests have been profound, yet are all too frequently overlooked or misjudged. In contrast to certain other sections where large burns may remain almost devoid of tree and shrubby growth for ten or twenty years, new growth quickly masks burns in the Pine Region, so that within five years inexperienced observers often fail to notice the damage. They assume that the present stands represent the potential forests of the region. This fallacious assumption has been commonly made by both foresters and laymen. Even experienced observers may occasionally fail to appreciate the great range in effects resulting from a single burn, caused by varying intensity of the fire, composition of the forest, size of the trees, or other factors. Intensity alone within a single stand may fluctuate widely with the size of the fire, position on its perimeter, and with burning conditions.

In this paper an attempt is made to show pictorially the effects of single fires and the cumulative influence of many past fires on the forest stands of South Jersey's Pine Region. This region differs from other sections of New Jersey in soil type and quality, in forest composition, and in the rate and kind of decomposition of the forest debris. For these reasons the following statements on fire history and effects are not always applicable elsewhere.



BACKGROUND INFORMATION

The Pine Region covers about 1.3 million acres in the southeastern part of the state, extending from the vicinity of Freehold and Asbury Park to Cape May, as shown in above illustration. The towns of New Egypt, New Lisbon, Medford Lakes, Atco and Bridgeton are either in or near the western edge of the Pine Region, which has never been extensively cleared for agriculture.



New Jersey Department of Conservation

The original forests were, it is believed, far different from those of today. Pines 6 inches and larger in diameter probably formed most of the stands on upland sites. On some areas oaks of similar size were interspersed among the pines. The trees stood rather far apart although their crowns formed a fairly closed canopy. There was little undergrowth, probably composed of small, scattered pines and oaks, together with low shrubs (chiefly blueberries and huckleberries), sedges, legumes, and other herbaceous plants. So open were many of the upland stands that travelers were able to ride on horseback or in carts without cutting a way through the forest. The descriptions by such early writers as Kalm (1748-1750 1/) indicate that original upland stands might frequently have had the appearance of the one shown above. Areas of low growth similar to the present "Plains" (page 21) may have been in existence, but certainly to a far less extent than today (Lutz 1934).

1/ See reference to Benson, 1937.

Dense stands of white cedars covered most of the swamp sites. "Some of these trees exceeded six feet in diameter and were more than a thousand years old" (Cottrell 1937). Here again early writers give the impression that stands, such as the one shown above, were about the average when the first settlers invaded South Jersey's forests.

Almost all of the immature deteriorated stands of the present are the result not only of fires, but of heavy utilization in early days. Beginning in 1684, iron furnaces and forges were established in the Pine Region. Their owners acquired wooded tracts of thousands of acres to supply the necessary fuel. Cedars, pines, and oaks formed the basis for extensive shipbuilding at the coastal and river towns. Lumber was sawed at countless small mills and used in building the towns of South Jersey as well as Philadelphia 2/. Glass and pottery factories within the region, as well as the homes and business concerns of nearby cities and towns, depended on wood and charcoal for fuel, so thousands of cords of firewood and immense quantities of charcoal were drawn from the forests of the Pine Region each year (Cottrell 1937).

2/ Lumber exports to more distant places were also common. "Great quantities of (white cedar) shingles are annually transported from Eggharbor and other parts of New Jersey, to the town of New York, whence they are distributed throughout the province. A quantity of white cedar wood is likewise exported every year to the West Indies.. ...." (written by Kalm in 1749).

All this exploitation was not carried on without its prophets of doom. Kalm in 1749 wrote that all the houses of Philadelphia would have to be rebuilt, because the supply of South Jersey cedar would soon be exhausted and the framing of the houses would not support the weight of slate or other heavy shingles that would have to be used. Kalm's prophecy was never wholly fulfilled, but by 1860 the industries in the Pine Region had largely collapsed -- due partly to the lack of suitable timber supplies and partly to the discovery of anthracite coal and richer iron deposits elsewhere in the United States (Cottrell 1937). Since 1860 operations in the Pine Region have been on a relatively small scale, but sufficient -- along with severe fires -- to keep the stands in an immature, degraded condition. Present cuttings are largely for fuelwood, pulpwood, small sawmill products, and occasionally for charcoal. (The above photograph shows charcoal still being prepared by the old "pit" method, the "pit" really being a pile of wood covered with turf and sand.) In most cases the cuttings are made without any thought of future use of the forest and are causing further deterioration in quality of growth.

In short, most of the heavy cuttings in Pine Region stands since 1684 have been so improperly conceived and executed that they have resulted in continued retrogression of the forest and increased susceptibility to fire injuries. Because the imprint of fires varies greatly with forest composition, the following discussion will deal separately with the oak-pine upland stands, the more deteriorated pine-scrub oak upland areas, the lowland pine stands, and the cedar-hardwood swamps.

UPLAND FORESTS

Well drained upland soils, mostly of the Sassafras or Lakewood series, have stands of oak and pine in varying mixtures. The best stands, those of pure pine, occur on abandoned fields (Moore 1939), usually near towns or villages where they are fairly well protected from fire. Such stands are rare. More commonly the upland forests consist of arborescent and scrub oaks mixed with pines.

The Oak-Pine Stands cover about 50 percent of the Pine Region. They are composed chiefly of black, white, chestnut, post, and scarlet oaks with pitch and shortleaf pines. There may also be a few blackjack, bear, and dwarf chinquapin (scrub chestnut) oaks. Nearly all the hardwoods are sprouts, many from large old stools (Moore 1939) resulting from repeated fires and frequent cuttings. Consequently the individual members of a sprout clump may stand rather far apart, giving the illusion of seedling origin, as in the five white oak sprouts shown above. Pines are of seedling or seedling-sprout origin, frequently less numerous than the oaks, but on the whole older and larger.

A typical oak-pine stand is shown above. There are scattered, large pines, like the one in the left foreground, and an almost continuous understory of sprout oaks. The pines may be from 1 to 70 years old, but the oaks are mostly of one age class. Those in the above photograph are 17 years old.

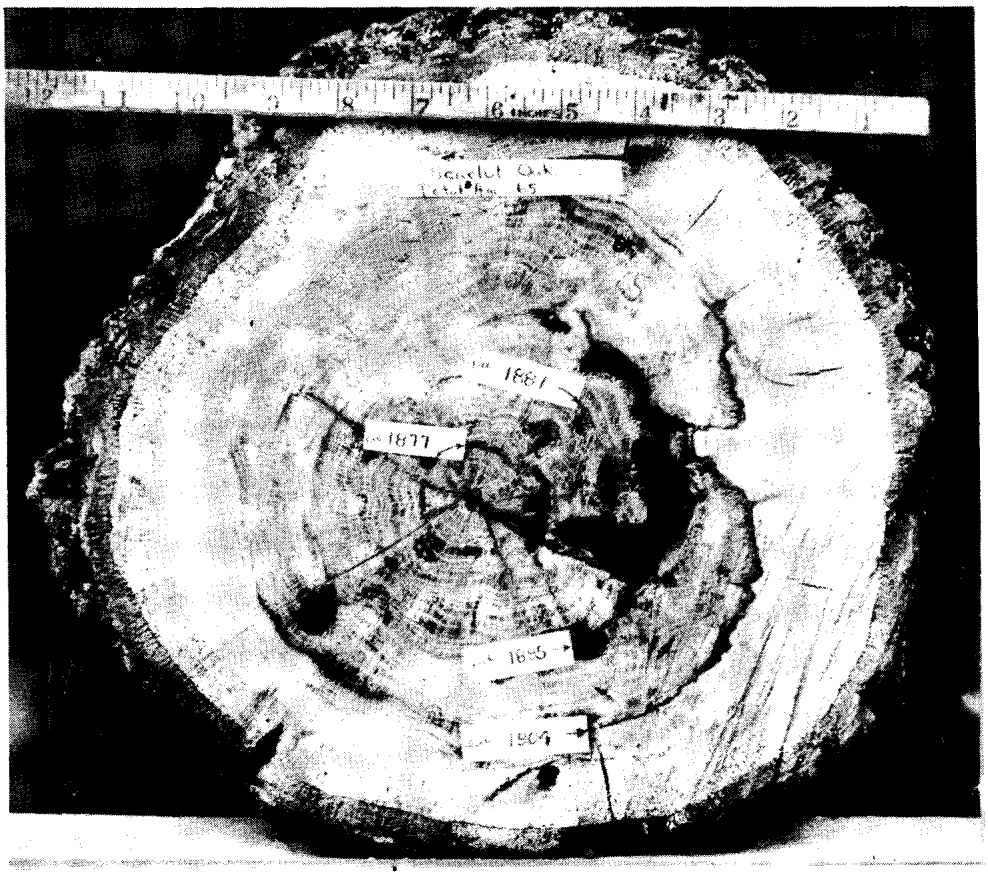
A better picture of such a stand can be obtained from the following table:

DISTRIBUTION OF STEMS IN A TYPICAL OAK-PINE STAND

Diameter at breast height	Distribution of: Oaks	Pines
Inches	Percent	
1 - 4	99.5	47.6
5 - 8	0.3	21.4
9 or more	0.2	31.0
Number of stems per acre	1410	105

Less common are the oak-pine stands where the hardwoods are of two or three age classes, starting as sprouts after periodic fires that killed only some of the existing oak stems. Such a stand is shown in the above photograph. The section of a stump, pictured on the opposite page, came from a scarlet oak in the above stand. The tree was 65 years old and bore the scars of four fires, indicating the frequency with which fires burn in this region.

Damage to oak-pine stands from single fires varies greatly. Direct damage occurs chiefly on the aerial portion of trees, because most of the root system is in mineral soil which is not appreciably heated by



any forest fire 3/. Only a few of the feeding roots are in the duff layer and may be burned. The amount of direct damage depends on species, size of trees, and fire intensity.

Typical fire damage in the oaks differs from that in the pines for two reasons. (1) the hardwoods have relatively thin bark so that less heat is necessary to kill the cambium of an oak than of a pine. (See Stickel 1940.) (2) Most of the fires occur either in the fall or early spring when some or all of the foliage has fallen from the oaks, so that fires more frequently burn into the crowns of the pines than into those of the hardwoods. Consequently most of the damage to oaks occurs from the killing of the cambium near the base, and not from injury to the crown, while damage to pines tends to occur more in the foliage and well-developed buds of the crown, with the basal cambium killed only by a more intense burn. (See data in paper by Little and Moore, 1945.)

3/ Heyward's (1938) work in the South indicated that increases in temperature, even under severe surface or surface-crown fires, are largely confined to the top $\frac{1}{2}$-inch of mineral soil. Less severe burns, particularly those that did not dispose of all of the duff, would apparently not create sufficient temperatures to injure any of the roots in mineral soil.

Size of trees is important because oaks and pines develop an increasingly thicker bark with age, thus rendering their cambium less susceptible to fire injuries. Also with increasing age and height, crown injuries decrease, since fires have to be of greater intensity to affect the crowns.

Fire intensity is important, because of both the amount of heat produced and its distribution. Fires which burn only the most exposed leaves or needles of the duff have low flames that usually do not exceed 2 feet in height. The heat from such a fire is not only small in volume, but is confined to a shallow zone. In heat intensity sufficient to affect buds or poorly protected cambium, this zone usually does not extend to mineral soil nor to a height of more than 2 feet. As more fuel is consumed, heat intensity increases not only within the first few feet, but in an increasingly wider zone. The expansion is however chiefly in an aerial direction, and only slightly into the soil (see Heyward 1938). As a result, larger and larger stems are affected either in the crown or in the cambium near the base.

Because strong head-fires burn with greater intensity than any other type of fire, they cause the most serious injury. Their heat is sufficient to kill large oak stems and severely deform the crowns of pines that do survive. The above photograph was taken at the end of the first growing season following a strong head-fire. All oaks have died back to their root collars, from which dormant buds have sprouted vigorously in most cases. Some of the large pines have survived by developing new crown sprouts (for example, two trees in center background).

Weak head-fires and strong side or backfires burn with much less intensity than do strong head-fires. As a result, the mortality of large trees is greatly reduced. For example, only about 10 percent of the oaks 9 to 13 inches in diameter are immediately killed 4/ by the weak heads or strong sides of large fires, as compared to 100 percent by the harder burning, strong head-fires. Similar reductions occur in the immediate mortality of pines and in the total mortality of both oaks and pines within a three-year period. (See data in tables on page 16.)

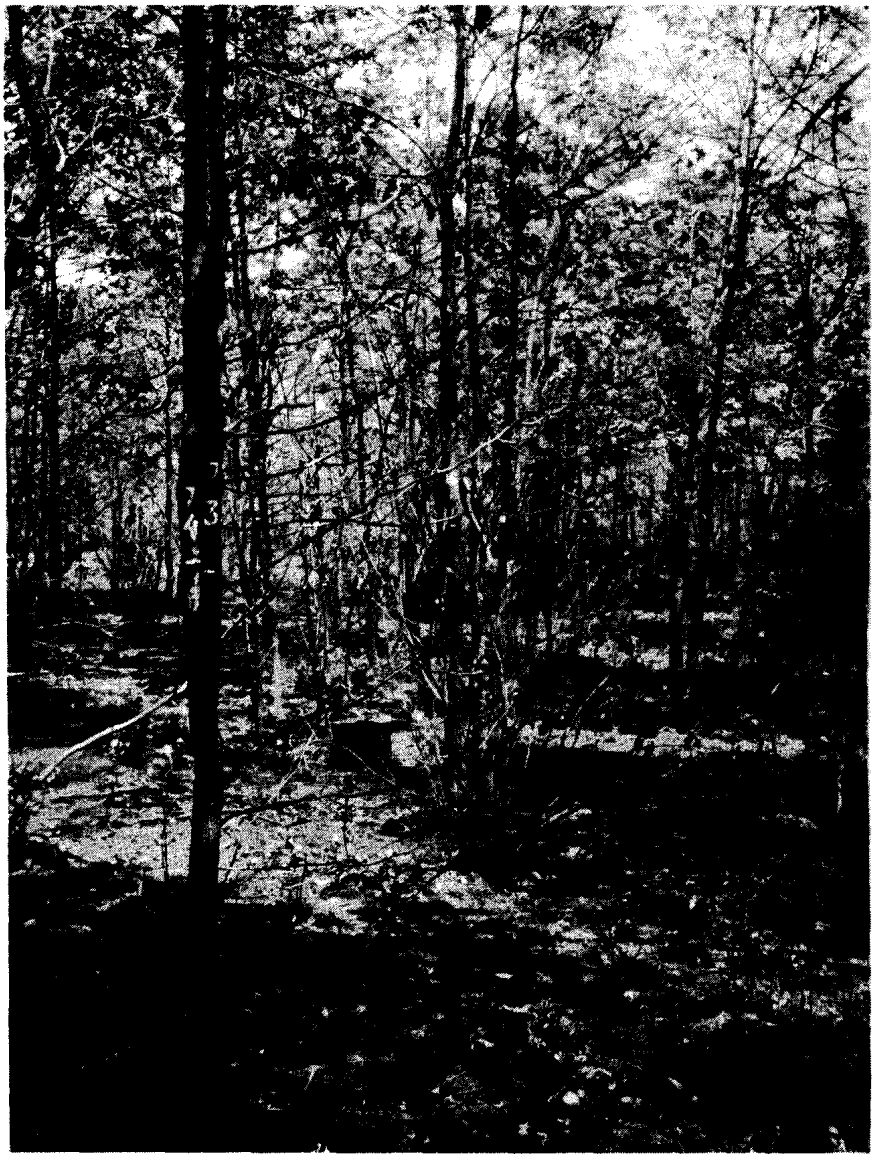
The above photograph shows the appearance of an oak-pine stand six

4/ Mortality data and "killing" in this paper refer only to the stems of the trees as they existed before the fire. Not considered in those terms are the survival of the root system and the development of new stems by sprouts from dormant buds at the root collar. The extent to which such survival and development occur varies with species, age and vigor of stem and root system. In general, shortleaf pine sprouts less vigorously than pitch pine. The latter and all the oaks may be considered as capable of vigorous sprouting, although there are differences between species in number of sprouts and in rates of growth (Little 1938). Trees of low vigor sprout less than those of high vigor; and large old individuals, less than smaller ones, although sprouting of the latter may be weak or even absent when the root system is too old.

weeks after a strong backfire had burned through it in early May. The backfire had been set to stop the side of a large fire. Most of the larger oaks have started weak crown growth, and the crowns of the large pines do not show as severe damage as that illustrated on page 10.

The oak-pine stand shown above was part of a burn of over 40,000 acres in early May. The weak head-fire of this portion of the burn did not have sufficient intensity to kill immediately all the larger oaks. Six weeks after the fire, when the above photograph was taken, even some of the oaks 2 to 4 inches in diameter had started weak crown growth. Most of these later died back, as a result of their fire injuries, and vigorous sprouts developed from the root collars.

The above photograph shows the same area as that on the opposite page, at the end of the third growing season following the burn. In this period the mortality of oaks 9 to 13 inches in diameter increased from the initial 10 percent to 90 percent on the burns made by the weak head or strong side-fires. Mortality of pines also increased in that period, but most of those over 5 inches in diameter continued to survive. Admittedly many surviving pines had crown injuries, but these were no greater on 4-inch trees than on the 10-inch stems burned by strong head-fires. (The pine at the extreme left of the photograph was 4 inches in diameter at the time of the fire. Note how it developed a new crown in the three years since the burn.)



Weak side-fires, even when occurring as parts of large burns, have still lower intensity and cause much less damage. Initial mortality of oaks 2 to 4 inches in diameter may be only 1 percent -- over 60 percent less than that from strong backfires. Representative of areas burned by weak side-fires is the stand shown above and on the opposite page. The view above, taken about a month after an early May fire, shows relatively light initial mortality, although this stand was part of a 9344-acre burn. Even subsequent mortality is not sufficient to prevent the survival and development of many of the original stems as the view on page 15, taken in the seventh growing season, indicates.

While damage throughout large burns varies with intensity of fire, major differences also appear between pines and oaks and between size classes. The summaries on the following page, which give initial mortality and that occurring within three years, show that:

1. Pines suffer far less mortality than oaks of the same size. (See also Little and Moore, 1945.)

2. In both oaks and pines mortality decreases greatly as size of trees increases, in the size groups where fire intensity is sufficient to kill some of the component stems.

The tables on page 16 also reveal the high amount of delayed mortality occurring in the classes where trees are severely injured, but are still living a few weeks after the fire. Such delayed mortality formed the basis for Stickel's suggesting in 1940 that damage appraisals should not be made until one year after the fire, by which time most of the delayed mortality would have occurred.

INITIAL MORTALITY AFTER LARGE 1/ FIRES IN THE OAK-PINE TYPE

Diameter breast height	Mortality of: Oaks in the area burned by: Strong head-fires	Weak head-fires or strong side-fires	Strong back-fires	Weak side fires	Pines in the area burned by: Strong head-fires	Weak head-fires or strong side-fires	Strong back-fires	Weak side-fires
Inches				Percent				
1	100	100	100	93	100	--	--	--
2 - 4	100	84	63	1	55	17	--	0
5 - 8	99	73	26	--	24	5	0	0
9 - 13	100	10	14	--	21	0	0	--
14 - 20	100	0	--2/	--	0	--	--	--
All Classes	100	77	44	16	29	9	0	0
Basis: Number of trees	554	304	116	92	167	44	20	6

1/ All over 1,000 acres in final size. 2/ No data for classes with dash.

MORTALITY WITHIN THREE YEARS AFTER LARGE FIRES IN THE OAK-PINE TYPE 1/

Diameter breast height	Mortality of: Oaks in the area burned by: Strong head-fires	Weak head-fires or strong side-fires	Strong back-fires	Weak side fires	Pines in the area burned by: Strong head-fires	Weak head-fires or strong side-fires	Strong back-fires	Weak side-fires
Inches				Percent				
1	100	100	100	93	100	--	--	--
2 - 4	100	99	83	18	100	28	--	0
5 - 8	100	94	54	--	68	5	10	0
9 - 13	100	90	14	--	35	0	0	--
14 - 20	100	12	--2/	--	0	--	--	--
All Classes	100	95	66	30	67	14	5	0

1/ Basis same as for initial mortality. 2/ No data for classes with dash.

Varying intensities of heat among different fires, like those of the various parts of a large fire, are reflected in differences in damage to the forest. For example, the initial mortality of oaks in the one-inch diameter class after a light winter burn may be only 15 percent of that caused by the weak side-fire of a large burn.

INITIAL MORTALITY OF OAKS AFTER A LIGHT WINTER FIRE IN THE OAK-PINE TYPE

Diameter at breast height	Basis	Mortality
Inches	Number of trees	Percent
1	186	14
2 - 4	243	1
5 - 8	22	0
9 or more	0	-
All classes	451	6

Size of trees and intensity of fire greatly influence the extent to which surviving pines develop deformed crowns, and the extent to which both oaks and pines form fire scars at the base of the stems. The smaller the surviving oak or pine, the greater is the probability of such damage; the hotter the fire, the larger are the trees that are injured. (See also Little and Moore 1945.)

The accumulated effect of past fires on present oak-pine stands of South Jersey is tremendous. Cutting and severe large fires have favored an increase of oak in the oak-pine stands (Moore 1939). Strong head-fires that killed back the oaks have played a major part in the continued coppicing of these forests, a coppicing that Little and Moore (1945) suggest has been on a 25 to 50-year cycle from 1800 to the present. Indeed it would appear that fires are chiefly responsible for the lack of oak seedlings in this region which Wood (1938) and Moore (1939) have described. Oak sprouts over 25 years old are frequently fire-scarred and defective as the result of non-killing fires. The pines are often in a similar condition, with crowns deformed in burns that killed back the associated oaks.

Although uncontrolled fires have been a bane to South Jersey's oak-pine forests, light winter fires when properly used may have favorable effects. They may be used to dispose of the debris on the forest floor and thus prepare the mineral seedbed necessary for the germination and establishment of young pines. The stand shown above originated on an area so treated. In other stands light winter burns may be of value in killing small oaks, without harming well established pine saplings (3 inches or larger in d.b.h.). Such fires serve also in reducing the amount of shrubs and duff so that accidental spring fires would have less fuel and thus cause less damage (Little and Moore 1945).

The cumulative effect of periodic light burns on present stands is far less disastrous than that of a single severe spring fire. For example, four light winter burns caused an increase of only 7 percent in the mortality of oaks (see table on opposite page), while one severe head-fire would have killed them all.

FOUR-YEAR MORTALITY OF OAKS ON UNBURNED AREAS AND ON AREAS BURNED ANNUALLY BY LIGHT WINTER FIRES

Diameter at breast height	Basis: number of trees 1/		Mortality - percent	
Inches	Unburned area	Burned area	Unburned area	Burned area
1	473	265	27	44
2 - 4	521	353	2	5
5 - 8	23	11	4	0
9 -13	5	3	0	0
All classes	1022	632	14	21

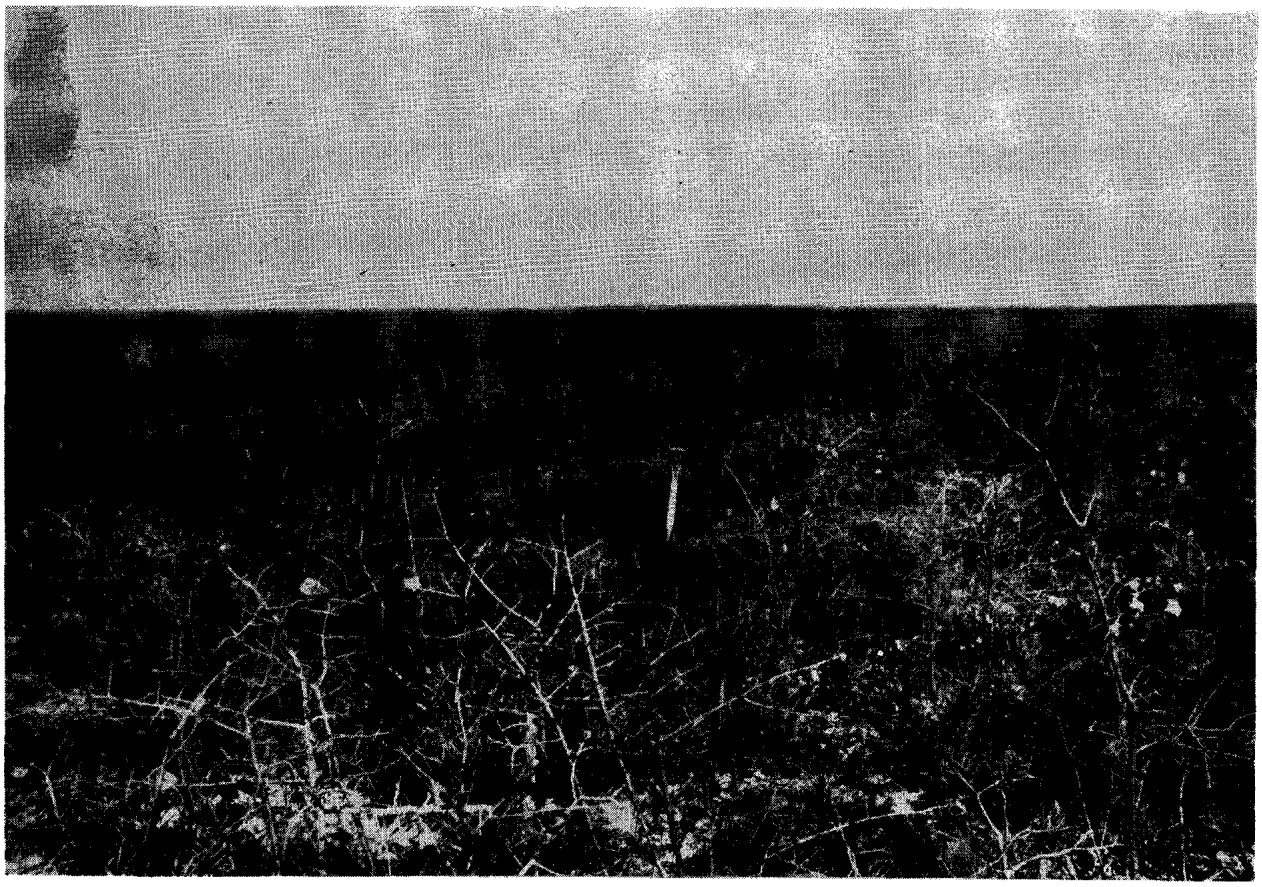
1/ On unburned plots totaling 0.8 acre and burned plots totaling 0.4 acre.

Even repeated light burns are not necessarily destructive to existing stands. The area shown above has been lightly burned each winter for 10 years. (Compare with the unburned portion of the same general stand on page 7.)

All available evidence suggests that light fires must have been fairly common before the white settlers arrived and that frequent light burns were responsible for the type of forest then in existence. Without cutting, the pines doubtless grew to greater ages than at present, provided more shade for the forest floor, and hindered the development of oaks, shrubs and other living fuel. With less fuel on the ground and with larger trees, even spring fires might not build up sufficient intensity to crown and thus injure the pine overstory. Holes in the canopy from natural mortality would doubtless be gradually filled -- usually not by oaks susceptible to fire damage, but by young pines which, when as small as 2 inches in diameter, might escape serious injury. (See also Moore 1939)

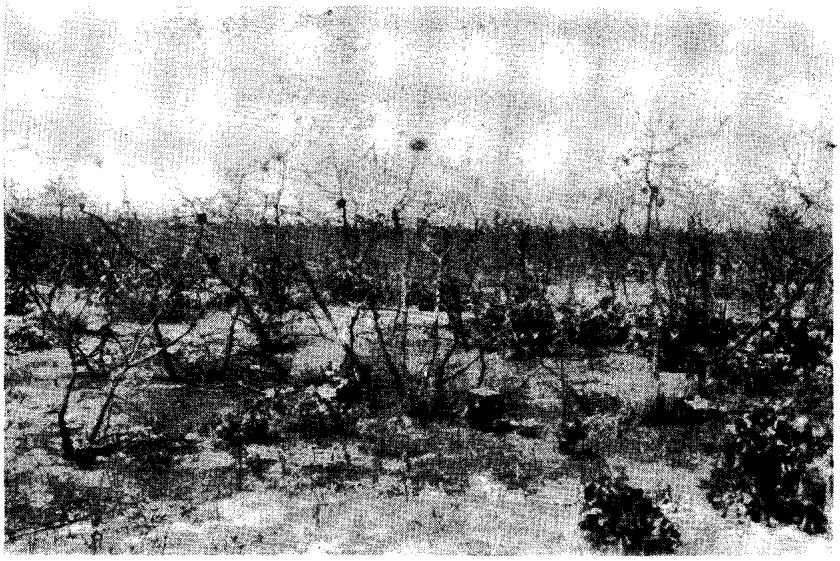
Early colonists apparently upset the equilibrium of these forests. In all probability fewer fires occurred during the early years, and an oak understory developed. Thus, following heavy cuttings of the overstory, the amount of oak increased -- as some of the early writers record. The heavy cuttings created stands of relatively small trees which were far more susceptible to fire damage than the larger stems of the original forest. At the same time extensive, hard-burning fires were favored by the more open stands and the greatly increased amount of fuel in slash, shrubs and small trees. Where these fires were not too frequent (20 years or more apart), stands became composed of a high percentage of the vigorously-sprouting oaks. The more resistant pines, although able to survive the fires to a greater extent, were frequently so injured that little seed was produced during the first few years after a burn. When pine seed was borne and distributed, the establishment of this species was frequently limited because of its mineral seedbed requirement for satisfactory germination, its intolerance and slower initial growth compared to the oak sprouts. As a result, only an occasional pine found a satisfactory opportunity for development.

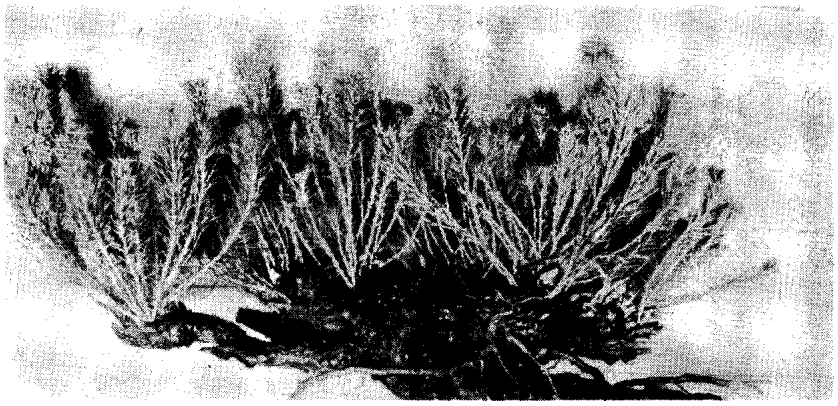
The Pine-Scrub Oak Stands occupy the more frequently-burned areas. Here the arborescent oaks and shortleaf pine are replaced by scrub oaks (bear, blackjack, and dwarf chinquapin) and pitch pine -- species that bear seed at an earlier age and sprout vigorously (Lutz 1934). To some extent the occurrence of pine-scrub oak areas may be favored by somewhat drier, sandier soils, but the major cause appears to be the greater frequency of severe fires. Some of the pine-scrub oak areas may have been in existence when the first settlers arrived in New Jersey. Such stands, even then, probably owed their existence to sandier soils and



more damaging fires than occurred in the oak-pine type. However, there is strong evidence (Lutz 1934) that the locations of pine-scrub oak areas change from time to time depending on the frequency of fires, and that pine-scrub oak areas have greatly increased in extent since colonial times. Many a tract that once supported a charcoal operation now has only "Plains" growth.

"Plains" growth is the low type of cover, chiefly sprouts of pitch pine and scrub oak, that occupies the most frequently burned sites (Lutz 1934, Moore 1939). A typical area is shown in the above photograph. Lutz (1934) estimated that this condition was created by severe burns at about 8-year intervals.





Photos by H. J. Lutz

The upper view shows a portion of the "Plains" about six weeks after the hot fire of July 19, 1932. Pitch pine here develops flat stools from which, after killing fires, sprouts arise in profusion. The stool shown in the lower view had 239 sprouts. These, developing after the fire of July 19, 1932, averaged 8 to 10 inches in height at the end of the 1932 growing season (Lutz 1934). On the basis of 79 stools examined one year after a killing fire, the number of living sprouts per stool may even then range from 3 to 249 and average 50.

Height differentiation among these sprouts is slow, being retarded to some extent by deer browsing, which is common on pines in this section (Little 1937), and by injuries from such insects as the Nantucket pine moth (Rhyacionia frustrana) or the Matsucoccus scale (Parr 1939). If, however, the sprouts are protected from killing fires, some of the stems gain a lead over their slower growing companions.

The area in the foreground of the above photograph was burned by the 1932 fire. Some of the resulting sprouts, now 13 years old, have attained dominance and are adding annually about a foot to their present heights of 8 to 12 feet. It is believed that the "Plains", if protected from killing fires, will change into taller pine-scrub oak stands such as the one illustrated on the following page.

The taller stands have been burned less frequently than the "Plains" --- i.e., at 12 to 16-year intervals compared to the 8-year intervals of the "Plains" (Lutz 1934). Moreover, recent fires in the taller stand were not intense enough to kill back all the pine overwood. Thus, as in the above stand, some of the trees may reach 40 feet in height, although their deformed crowns still show the effects of past fires.

This injury is particularly noticeable where the stands have been burned within the last 5 years by a fire intense enough to kill back some of the large pines and to deform seriously the crowns of many others. Compare, for example, the stand shown above with that on the preceding page. The latter has not been burned for 15 years. The photograph reproduced above shows an adjoining area at the end of the third growing season after a fairly intense fire.

More severe burns may kill back the large pines and convert the area to "Plains" growth. In 1935 the stand shown above was probably similar to that on page 24; but in 1936 most of the large pines were killed back by an intense fire, part of a 46,000-acre burn. Another fire severe enough to kill the few surviving stems would complete the transition of this area to "Plains".

Not all of the burns in the pine-scrub oak type are intense enough to affect the pine overwood. The stand shown on the opposite page was part of an area of 11,225 acres burned in April 1943, two growing seasons before the picture was taken. Because of high fuel moisture and low intensity of burn at the point shown, only the scrub oaks and smaller pines were killed. (Examples are the pines beside the axe and the one in the extreme left foreground, all of which sprouted from the base.) The larger pines did not even have their crowns deformed -- an injury that on these trees usually requires less heat than is necessary for basal scarring.

Fires of low intensity, characteristic of controlled winter burning, have not yet been used in pine-scrub oak stands for specific management purposes. Information obtained from the controlled burning of oak-pine stands, together with that from chance fires as on the above area, indicate that light winter fires might be used in reducing the fuel accumulations on certain pine-scrub oak areas. These tracts should contain sufficient pines 2 inches and larger in diameter to form a closed stand before the trees are 6 inches in diameter. Even light winter fires should be excluded from the young stands of "Plains" growth because there the burns would usually be more destructive than beneficial. The possible role of light winter fires in the silvicultural management of the various pine-scrub oak areas has not yet been explored. Because these fires may be of value in greatly reducing the stocking of scrub oaks and in securing seedling-pine stands of far higher quality, their possible role warrants investigation.

LOWLAND FORESTS

Between the streams and the upland stands of pine and oak occur lowland forests of two broad types. These are (a) the white cedar --hardwood stands of the true swamps and (b) the pine swamps on the adjoining flats. The latter areas have a water table that is usually within 30 inches of the surface, and they support stands predominantly of pitch pine. Slightly moving or stagnant surface water, particularly in the small hollows between hummocks, is characteristic of white cedar--hardwood swamps. Soils of the pine swamps are chiefly sands of the St. Johns or allied soil series, while those of the white cedar--hardwood sites are frequently peats of varying depths.

Pine Swamps. The fire history of the pine swamps differs in two ways from that of upland stands.

1. Fires occur on fewer days throughout the year than on upland sites because, as a result of the poor drainage and high water table, fuels in the pine swamps dry less readily.

2. Because of the dense understory of inflammable shrubs (leather leaf, sheep laurel, bayberry) the fires that do occur tend to crown to the tops of the pines.

The intensely burning fuel of the pine swamps tends to produce fewer gradations in fire damage than occur on upland areas. Variability in moisture content and possibly in amount of fuel is the reason why certain fires in these swamps may crown in one spot and not burn at all in a moister spot a few yards away.

The effect of single fires varies, of course, with fire intensity, and different types of fires may result in a wide variation in damage. This is indicated in the following table.

INITIAL MORTALITY IN PINE SWAMP STANDS FROM THREE TYPES OF FIRES

Diameter at breast height Inches	Mortality of pitch pines on areas burned by: Large spring fire	Legal fire on intermittently burned area 1/	Light winter fire on previously prepared area 2/
		Percent	
1	100	82	3
2 - 4	98	30	1.5
5 - 8	40	7	1
9 or more	--	0	0
All classes	98	45	2
Basis: number of trees	306	1348	832

1/ Near a cranberry bog and burned only once every 7 to 10 years.

2/ Much of the underbrush cut, stand thinned by removing poorest and smallest members, slash piled and burned.

Large spring fires frequently kill back nearly all the pines under 5 inches in diameter, as on the area shown above. This was part of a 9,344-acre May fire and was photographed at the end of the first growing season following the burn. Mortality tends to be less on areas legally burned 5/ for the protection of cranberry bogs, even

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5/ Fires set legally to burn a protective strip around bogs are usually started along roads and are allowed to burn back toward the flooded bogs. Such broadcast burning has customarily been done in late March or April. Because of drier fuels, the fires tend to be of much greater intensity than controlled winter fires, although of less intensity than large uncontrolled fires occurring during periods of still drier fuels.

though such burning is usually done in March or April, often at times of medium fire danger. Where legal burning is intermittent, so that fuel accumulations build up sufficiently to provide material for a hot fire, the resulting damage approaches that from an uncontrolled fire. Under such conditions mortality of 1-inch pines may exceed 80 percent; and most of the surviving pines, up to 4 inches in diameter, will probably have their crowns deformed.

Typical damage on areas intermittently subjected to legal burning is shown above. This photograph was taken at the end of the first growing season following one of the periodic burns at 7 to 10-year intervals.

Where the legal burnings are carried on annually, fuel accumulations are small and damage from a single fire is greatly lessened. According to one local resident, the stand shown above has been legally burned each spring for over 30 years.

Damage from a single fire can be further decreased if:

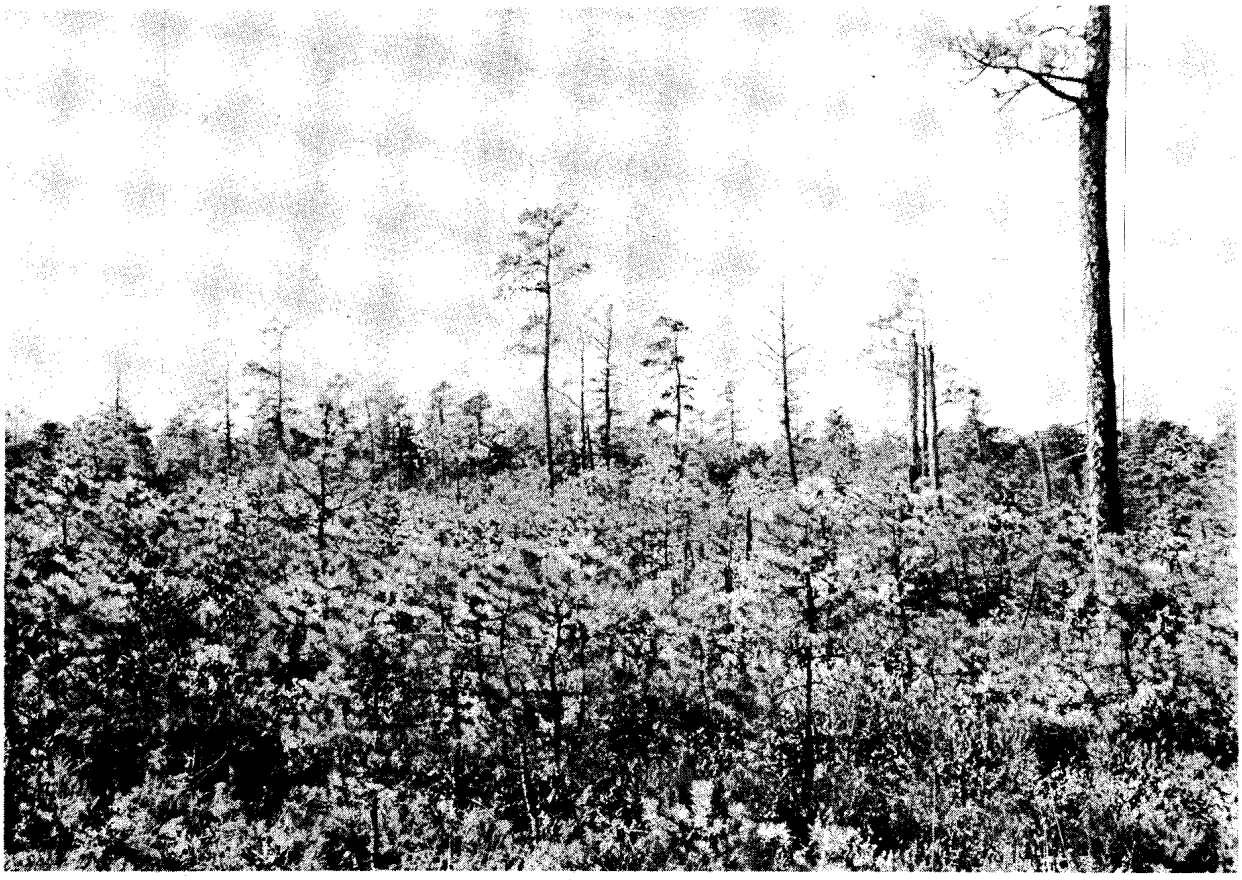
1. The fuel is first reduced in amount through cutting, piling, and burning much of the shrubby understory.

2. The broadcast burning is done only in the winter at times of low danger. The stand shown above, photographed at the end of the first growing season after burning, was treated in this way.

The cumulative effect of fires on pine swamp stands has been:

1. To favor pitch pine over such hardwoods as red maple and black gum. Apparently the successional trend, if not checked by fire, would be toward pure hardwoods. On areas unburned for 20 years, such as the one shown above, a dense understory of shrubs, black gum and red maple frequently develops. (The pines in the illustration, of course, survived the last fire).

2. To produce a fairly uniform overstory of pines, with a light understory of shrubs, on areas frequently burned by light fires. Compare the stand shown above with those on pages 32 and 34. The above stand is in the same general area as that shown on page 33, but has had three additional light winter fires, the last three growing seasons before the photograph was taken. (The smaller pines in the above stand are sprouts following a severe fire 20 years ago.)



3. To produce stands of young, crooked pitch pine sprouts through severe killing fires. Because of the frequency of these fires, most pine swamps are stocked by such stands. Scattered among the sprouts may be older pines with deformed crowns. Typical of areas burned by severe fires is the one shown above. The small stems are sprouts following a burn 12 years earlier, which the larger, deformed pines in the background survived.

While information on the management of these sites is far less complete than for the upland oak-pine stands, it is believed that here too pine is the most desirable species. If this belief is correct, light winter fires in the pine swamps may be a useful management tool -- in reducing fuel accumulations, in preparing a suitable seedbed for the establishment of pine seedlings, and in controlling the less valuable hardwood associates.

White Cedar-Hardwood Swamps differ greatly from both the upland forests and the pine swamps, in that:

1. Fires seldom start and spread on the wet sites of the true swamps stocked with white cedars and hardwoods.

2. Light winter fires are not possible on these wet sites nor are they desirable in view of white cedar's susceptibility to fire injuries.

3. Unlike pitch and shortleaf pines, white cedars do not sprout at all after a fire has killed their stems but left their root systems undamaged.

4. Because of the peat soils, ground fires may occur during severe droughts and kill entire trees of any species through destruction of the root systems.

Damage to the white cedar-hardwood stands has been chiefly the result of large fires originating on drier sites. Although in many cases the swamps have served as natural firebreaks, their stands have often been partially killed in the process, sometimes creating a meadow as in the above view.

Occasionally the head of a large fire will crown across a white cedar swamp, killing the entire stand, as in the view shown above.

The effect on succeeding stands varies. If the fires burn into the peat and destroy nearly all existing hummocks, tree growth may not become re-established for a long time. This is probably the reason for the lack of tree growth in the narrow swamp shown above. However, damage of this type is generally confined to narrow swamps or the edges of wide ones.

Other burns may be restocked by nearly pure white cedar stands provided there is sufficient seed stored in the peat, or shed by a neighboring stand, and competition from hardwood sprouts is slight. (See also Korstian and Brush, 1931, and Moore and Waldron, 1940). Some burns come back to hardwood sprouts, chiefly red maple, black gum and sweet bay. These species, even when mature, are practically worthless on these sites.

On the above area part of the original white cedar stand was killed by a large fire that crowned across the swamp. In spite of nearby white cedar seed sources, the hardwoods are restocking the burn.

SUMMARY

In concluding this discussion of forest fires in New Jersey's Pine Region, the following salient points have been selected for reemphasis.

1. Forest fires were evidently common even before the first white settlers arrived. In the uncut upland forests the effect of these fires was to maintain a high percentage of fire-resistant pines and a relatively low percentage of oaks.

2. Because of the composition of the stand and the fuel, it is believed that these early fires were of relatively low intensity and generally permitted the development of stands of good quality.

3. Beginning about 1680, extensive cuttings in the Pine Region greatly increased the amount of fuel, both in slash and in shrubs and small trees developing in the openings. The cuttings also created immature stands very susceptible to fire damage.

4. After the first heavy cuttings, extensive and severe fires became common and have been largely responsible for the present deteriorated upland stands.
   (a) Where such fires were not too frequent, oak understories developed and these, when cut or killed back by fire, produced rapidly growing sprouts that crowded out most of the pine seedlings. As a result of repeated cuttings and fires, present stands usually contain scattered deformed pines and a dense understory of oak sprouts arising from large stools.
   (b) Frequent severe fires favored stands of pitch pine and scrub oaks. These species occupy more extensive areas than formerly, and develop a low, almost prostrate growth on the most frequently burned tracts. This type of cover, while probably antedating the colonists in a few limited localities, has expanded since settlement. Such low growth now occurs also on areas which are known to have formerly supported commercial stands.

5. Hardly a single upland stand of today resembles the forest found by the colonists.

6. Lowland stands also have been greatly injured by the severe fires of the last 200 years.
   (a) As a result, most of the present pine swamps are stocked with poorly formed young sprouts or deformed old stems.
   (b) Some white cedar--hardwood stands have been destroyed by deep burning fires which eliminated all tree growth for many years. More commonly the large fires have crowned across white cedar swamps, killing the valuable cedars and resulting at times in stands of worthless hardwoods.

7. Nearly all the extensive damage described above has been caused by the hot heads of large fires.

8. Damage decreases greatly with lessened fire intensity. Thus weak head-fires or strong side-fires, even when parts of large burns, are less damaging than strong head-fires. A further decrease in injury accompanies the lower intensities of weak side-fires; and the least injury of all occurs with the very low intensity of a light winter fire.

9. Where fire intensity is not sufficient to kill all of the stand, damage varies inversely with tree size. Thus, where pines 4 feet tall are killed, those 4 inches in diameter might not be damaged.

10. While the elimination of large fires is essential for the production of commercial stands in the Pine Region, light winter fires may be decidedly beneficial under certain conditions on all sites except the white cedar--hardwood areas. Used at the right times and <u>properly supervised</u>, light fires may be effective in favoring the more valuable pines at the expense of associated low-grade hardwoods. The light fires are also of value in reducing the amount of "rough" and so lessening the danger of large severe fires. Light fires are quite useful too in exposing mineral soil and thus encouraging the establishment of pine reproduction. In all of these respects light winter fires may be taking the role of the pre-settlement fires which shaped the development of most of the original upland stands in New Jersey's Pine Region. (For more detailed information on the use of light winter fires, see paper by Little and Moore 1945.)

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